DOCUMENT RESUME

ED 237 123 JC 830 491

AUTHOR Capps, Joan P.
TITLE Mathematics for the Technical Student: The Use of the Computer in the Systems Approach to Instruction.
PUB DATE May 83
NOTE 33p.; Paper presented at "Vocational Education in the Community College," the New Jersey Consortium on the Community College Conference (Atlantic City, NJ, May 19-20, 1983).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Descriptive (141) -- Guides - Classroom Use - Materials (For Learner) (051)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Community Colleges; *Computer Assisted Instruction; *Flow Charts; Mathematical Concepts; Mathematical Logic; *Mathematics Instruction; Mathematics Materials; *Technical Mathematics; Two Year Colleges

ABSTRACT

An instructional method using flow-chart symbols to make mathematical abstractions more concrete was implemented for a year in a technical mathematics course. Students received instruction in computer applications and programming in the BASIC language in order to increase motivation and firm the mathematical skills and problem-solving approaches necessary for understanding. The flow-charting technique was used only when appropriate, for example, to teach a new procedure which was presented as an algorithm; to clarify proofs of mathematical rules; to help students solidify concepts; and to analyze English descriptions of quantitative problems. Year-end results included development in students' mathematical abilities and noticeable improvement in their understanding of a variety of topic areas. In addition, the following attitudinal improvements were observed: (1) increased quantity of the work done outside of class; (2) lively class participation; (3) high attendance; (4) use of conference time with instructors; (5) seeking of extra mathematics sessions; (6) decrease in math anxiety; and (7) improved retention of concepts. The appendix includes exercises, flow charts and other matherials used in the course. (LAL)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED237123

MATHEMATICS FOR THE TECHNICAL STUDENT: THE USE OF THE COMPUTER IN THE SYSTEMS APPROACH TO INSTRUCTION

Joan P. Capps

SOMERSET COUNTY COLLEGE
P.O. Box 3300
Somerville, New Jersey 08876

May 1983

JC 830 491

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

J. Capps

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

X Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

1. Introduction. The teaching of mathematics presents the unusual difficulty among the various subject fields in view of the fact that mathematics is deductive whereas the learning process in general is inductive. The special problem in teaching the technical student is that he/she is a practical-minded person who must deal with things rather than with words or ideas. The individual differences among students in experiences, mathematics background, interests, and maturity are more diversified than found in other college mathematics courses.

However, in this period of technical change, the student who is training for a career in technology must not only be able to use mathematics as a tool, but must be able to understand the concepts involved in order to be able to use mathematical logic in applications to physics, electronics, electrical technology, automotive technology, etc. in order to keep up-to-date with the rapid changes in the field.

The close relationship of computer science and mathematics suggested that the systems approach to thinking and decision making used by computer scientists could provide the concrete concepts necessary for the student to have the patience to deal with the generalities and abstractions necessary to understand mathematical concepts. The model used to make abstractions concrete was the flow-chart, using the geometrical symbols which conform to the International Organization for Standardization (ISO) International Standard 1028 - "Information Processing Flowchart Symbols", and the American National Standard, Flowchart Symbols and Their Usage in Information Processing (Schriber, 1969). Computer applications and programming in the BASIC language were presented for motivation and firming the mathematical skills and problem solving approaches necessary for understanding.

2. Elements in the Systems Approach. The systems approach to thinking and decision making used by the computer scientist includes the following features or elements (Pfeiffer, 1968):

1. Design for Action. Finding the right questions to ask is half the battle; only after you know clearly what it is you want to learn can you proceed to come to grips with your problem. Thus, defining the problem in operational terms in ways that demand concrete action is the first element.
2. Seeking Alternatives. Identifying and outlining the various methods of meeting each objective require open-mindedness and readiness to discard preconceived notions.
3. Evaluation. Checking the effectiveness of the method, modifying if necessary, and repeating the checking-modifying procedure until perfected is the most important element.

Basic to the entire systems notion of decision-making is the concept of a model - a simplified but controllable version of a real world situation. The model that I used to simulate the real life situation of a mathematical problem-solving environment was the flow-chart.

3. Supportive Research. The literature of instructional development consists of increasingly more precise discussions of methodology and attempts to construct empirically-based simulation models. Some of the greatest advances in the science of instruction (Glaser, 1976) are derived from recent research on concept acquisition. This has led to developing new ways of mapping the structure of content to be taught and then deriving from that structure direct prescriptions for presentations of explanations, examples, and practice to students (Merrill, Reigeluth, and Faust, 1979).

Instructional developers emphasize that the basis of their approach is a systematic process of decision making about instructional problems, not the use of any particular gadget (Briggs, 1977). Thus, technology implies a problem-oriented, interdisciplinary approach to inquiry with great emphasis on the discovery of regularities and principles about the way in which design and implementation decisions are made.

In addition, the instructional environment is modeled more precisely by applying research on motivation to elaborate earlier behaviorally-based models of the instructional environment. Failure of educational

programs are at the stage of converting visual concepts into functioning reality. Thus, conversion of theory into practice (Keller, 1979) is the problem which should be addressed in instructional design.

4. The Flow-Chart . The technique presented in this paper attempts to aid the student in translating the theoretical concepts of mathematics into concrete concepts which are workable.

Initially, the class was presented with the concept that a computer is a giant moron whose thought processes must be guided through a step-wise procedure. Emphasis was placed on the fact that these thought processes indicate the components of a computer, which can be diagrammed by the use of various geometrical shapes. The fact that various decisions were necessary before a process could be executed was illustrated by flow-charts showing the decisions needed to exercise simple procedures. The necessity of asking questions, indicated by the diamond shape, before performing any process emphasized the abstract analysis which is mandatory in all decision-making - real life as well as mathematics. Various examples were assigned to clarify the concepts of flow-charting using life situations. See Figures 1 through 5.

The fact that the whole procedure could be visualized easily by following the arrows on the flow-chart was illustrated by various evaluations of functions in mathematics. Thus, algebraic and arithmetic computation skills were reinforced. Problems such as printing the value of a reciprocal if not zero, doubling the larger of two numbers, determining whether a number is positive or negative, Heron's formula, reading the coordinates of a point in a plane and deciding the number of the quadrant in which the point lies emphasized that attention to detail is necessary in all mathematical calculations. Figures 6 and 7 are composites of problems presented for practice in substitution and those presented as examples to give practice in mathematical formulas as well as evaluation procedures.

Figure 8, The Function Machine was presented to the class to correlate the concept of domain and range of a function in mathematics with

the input value to an algorithm, defined by a processing statement, to give a range value. When presented as computer exercises, the fact that the range values must be able to be calculated using the real number system clarified the exclusions to the domain.

Thus, the flow-charting model using computer implementation presented a holistic view of the logic of the problem with complete clarifying detail before the introduction of the mathematical symbolism. Observable results indicate that students recognized that all aspects of a problem had to be explored and that mathematics defines and simplifies thought processes. Interest in algebraic and trigonometric methods to simplify complex concepts evolved.

5. Classroom use of computers/flow-charting. It is important for the instructor to use the flow-charting technique with discretion. The aim of the course is to teach mathematical logic and skills with understanding and not to teach computer programming. Thus, the choice of the Basic language with its algebraic structure was an excellent vehicle to implement the flow-chart design and to reinforce algebraic concepts.

As the student familiarized himself/herself with computer hardware and terminology such as RAM (Random Access Memory), bytes, K (kilobytes), terminal, etc. , applications which emphasized the need for greater computational skill became commonplace. Thus, motivation for arithmetic review, precision and accuracy, and measurement topics was sparked by examples from Kramer(1979, p. 569) such as:

> "The speed of a typist in words per minute is given by s = n/6 where n = number of characters including blanks. A modern high-speed printer prints 1200 lines/minute. If each line contains 130 characters, what is the speed of the printer in words per minute?"

The need for scientific notation as well as exponentiation was discovered by students when confronted with problems using the metric system such as (Kramer, 1979):

"Retrieval from memory can be extremely fast. If one bit can be retrieved in 80 nanoseconds (1 nanosecond = 10^{-9} seconds), how many words can be retrieved in one second?"

The large and small numbers, not directly transferable to the calculator, gave credence to the fact that computers are tools which are limited by the mathematical ability of the programmer.

The flow-charting technique was used as a method of instruction when the holistic approach to problem solving was deemed necessary. Thus, it was used to:

1. teach a new procedure which was presented as an algorithm. An example of this use is Figure 9, Third Order Determinants.
2. clarify and make more meaningful proofs of rules presented. The student did the research independently and developed the logic of the rule as an outgrowth of previous knowledge and not just as another confusing fact to memorize. Figure 10, Pythagorean Theorem is as example of this use.
3. help the student to solidify concepts to dispel insecurity and ambiguity when doing homework assignments. The monotony of repetition was kept at a minimum since each problem required analysis. Two noteworthy examples are the Quadratic Equation and the Evaluation of a Polynomial in Figures 11-12.

6. Use of flow-charting in applications. Technical mathematics classes frequently include students who have previously avoided mathematics because of a feeling of insecurity or a genuine distaste for the subject. Because learning is colored by emotions, consideration of feelings toward the subject is particularly important in establishing a desirable learning situation. Favorable attitudes are, of course, a necessary but not a sufficient condition for learning. In other words, though desirable attitudes do not guarantee successful experience, learning takes place only if the pupils develop favorable attitudes toward the subject. Flow-charts provide the "blue-

prints" for clarity and accuracy, help to overcome the anxiety of an incompleted plan, and introduce a "real-world" technique into the classroom environment.

In word problems, the difficulty of unifying the various elements learned into one whole unit is accentuated by the reading-comprehension difficulties of many technical students. Thus, as an aid teaching the analytical skills necessary to carry out the development from the concrete to abstract, to make broader use of technical applications, and to provide the time element needed for discovering relationships among various mathematical concepts, the flow-chart organizes the entire analysis into blocks or units which can be addressed as a part of the whole. Attention can be shifted to the importance of each measure, to some particular computation, or to extensions of the application. Always in the end, however, the detail should be returned and integrated with the major concern of the application as indicated by the flow-chart.

The interconnections between quantitative reasoning and English terms make word problems difficult to teach. The importance of teaching applications is obvious, not only from a motivational point of view, but since all areas use mathematical concepts. The flow-chart in Figure13 was presented as a guide to analyzing the English description of a quantitative problem. It is readily seen that the inter-relations of the parts of the analysis to the whole problem were clarified by the flow of the outline. The fact that one can follow the entire argumentation easily before the use of algebraic symbolism increases the probability that the solution will make sense from a logical point of view.

The importance of broad understandings through a grasp of relationships is as great in all decision-making areas. Thus, this model was presented to the student to help solve his every-day problems. The result was a better grasp of mathematical decision-making as well as an improvement in the use of deductive reasoning skills.

7. Observable results at the end of year. Since the flow-chart form of instructional design was used for one year, there has been no opportunity to obtain a quantitative measure of the success of this technique over another technique. However, there was an observable improvement in the mathematical abilities of the students and a noticeable development of desirable attitudes.

A final examination in Technical Mathematics, which contained questions from the College Algebra and Trigonometry finals given to students in science-preparatory classes, resulted in an average grade of 74.3%. Although the average grade of students in the science-preparatory classes was 73.6%, no definite conclusions can be reached concerning the flow-chart method due to the fact that the tests varied due to the technical and theoretical nature of the courses. However, there is no doubt that the technical mathematics student, who entered with a weaker background and mathematics anxiety, improved more than the science-oriented student.

There was a noticeable improvement in the following topics.

1. The Associative, Commutative, and Distributive Laws were part of the student's thought process when using mathematical operations. Problem areas, such as $2x^0$ versus $(2x)^0$, $(x^{-2} + y^{-2})^2$, $-(x - y)^2$, etc. have been eliminated or recognized as errors if done incorrectly.

2. Fractional exponents were used to clarify radicals automatically by students.

3. "Cancelling"problems were minimized since the division operation was used.

4. Fractions were not the former dreaded "foe". Students recognized the denominator as the base of a term which must be the same to combine with another term. The numerator was recognized as the coefficient of the base as in programming a computer problem.

5. Application problems were approached with the aim of understanding the entire problem before doing calculations. The necessity of careful documentation was an observable characteristic of the student's work.

6. Trigonometric functions were understood as ratios of sides with respect to an argument which was used as the input to the function.

Thus, no confusion with inverse trigonometric functions developed.

7. Circular trigonometric functions were defined carefully in terms of their reference angles. The emphasis on detail was noteworthy.

8. The Law of Sines and Cosines were used correctly. Since the ambiguous case in the Law of Sines was programmed, attention was paid to the given parts.

9. Fractional polynomials were understood as requiring the lowest common denominator and the reasons for multiplying fractional equations by the lowest common denominator were understood.

10. Conversions to metric system were treated correctly since the students used the units to indicate the necessary mathematical operations.

11. Quadratic equations were solved intelligently. Recognition of the importance of the discriminant and nature of the roots led to the use of the simplest solution technique.

13. Cramer's Rule was easily used and preferred as a technique for solving systems of linear equations.

14. The concept of function was clearly understood since the domain was equated with input and the range was equated with the output of a computer program.

The desirable attitudes which indicate the success of the technique include:

1. the quantity of work done outside. Special projects done in conjunction with technology courses in refrigeration and air-conditioning were worked for extra credit projects. One student calculated and flow-charted the air-conditioning requirements for a house that he and his wife were designing and building.

2. lively participation in classroom discussion. One student set the procedure for factoring a cubic sum and difference polynomial to music.

3. attention in class and attendance. If absent, students always called or conferred with me to learn what was missed.

4. conference time was used and sought. This was especially noteworthy since the students had their technical laboratories about 20 minutes from the main campus.

5. seeking of extra mathematics sessions to improve understanding.

6. mathematics anxiety decreased. Many students are planning on taking Calculus.
7. retention of concepts and carry-over into other courses. The technical students are succeeding in Technical Physics this semester without the mathematical problems that students in previous years have had.

The following evaluation was written by a student who is 45 years old and has one of the most serious cases of mathematics anxiety seen by the counselor in charge of the course.

> "The flow-chart structure to solving word problems enables me to pinpoint the area in which I am having difficulty. This enables me to concentrate on this area rather than dismiss the whole problem and give up. It also enables me to ask my instructor for specific assistance."

8. Conclusions. The flow-charting technique of instruction described in this paper addresses the problem of converting theory into practice (Keller,1979). The results give credence to the statement of the President's Scientific Advisory Committee over a decade ago (1970, pp.7-8):

> "In all fields where computing has been used, it has added a new dimension to education and has led the students to better comprehension of complex problems and greater insight into the meaning of quantitative expression. In these areas undergraduates have learned through preparation of and experimentation with computer programs of the care required to define a problem logically and fully, and the assumptions needed to obtain answers to complex problems."

Although the technique was used successfully with Technical Mathematics students, flow-charting has the potential for utilization in instructional design for any course in mathematics, science, or decision making.

REFERENCES

Becerril, J. L. et al. "Grammar Characterization of Flow Graphs." IBM Journal of Research and Development 24: November 1980, 756-763.

Briggs, L.J., Instructional Design: Principles and Applications, Prentice-Hall, Englewood Cliffs, New Jersey, 1977.

Glaser, R., "The Components of a Psychology of Instruction: Toward a Science of Design." Review of Educational Research 46. Winter 1976, 1-24.

Keller, Clair W., "Using Creative Interview to Personalize Decision Making in the American Revolution." Soc. Educ. 43: March 1979, 217-220.

Kramer, Arthur D., Fundamentals of Technical Mathematics, McGraw-Hill, New York, 1979.

Merrill,M.D., Reigeluth,C.M., and Faust, G.W., "The Instructional Quality Profile: A Curriculum Evaluation and Design Tool." In Procedures for Instructional Systems Development, Chapter 6. Edited by H.O'Neil. Academic Press, New York, 1979.

Pfeiffer, John, New Look at Education: Systems Analysis in Our Schools and Colleges, Odyssey Press, New York City, 1968.

President's Scientific Advisory Committee, "Computers in Higher Education, Report of the Commission to the White House, February 1967." Government Printing Office, Washington, D.C., 1970, 7-8.

APPENDIX

TABLE OF CONTENTS

Figure 1... A Computer for the Naive Reader

Figure 2... Computer Components

Figure 3... Flow-Chart Symbols used in Tech Math

Figure 4... Procedure for Crossing Street at Intersection

Figure 5... Alogorithm for Changing a Tire

Figure 6... Flow-Charts for Tracing Problems: Substitution of Numbers

Figure 7... Flow-Charts for Mathematical Detail Classroom Exercises

Figure 8... Function Machine to explain Domain and Range

Figure 9... Procedure to Solve Third Order Determinants used as handout for classroom work

Figure 10.. Proof of Pythagorean Theorem.. Classroom exercise

Figure 11.. Polynomial Evaluation with Listings of Computer Program

Figure 12.. Quadratic Equation with Homework Problem

Figure 13.. Word Problem Solving Guide

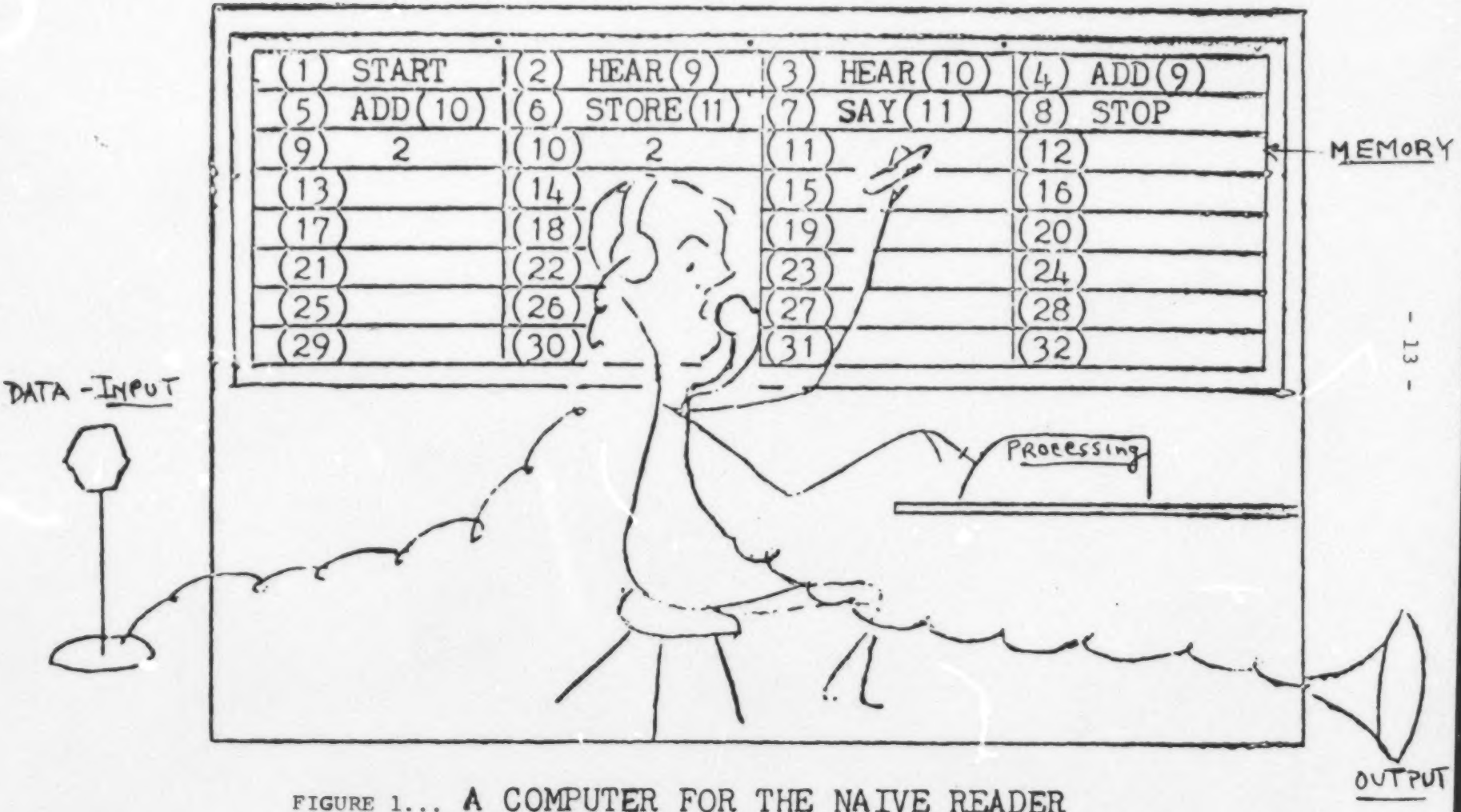


FIGURE 1... A COMPUTER FOR THE NAIVE READER

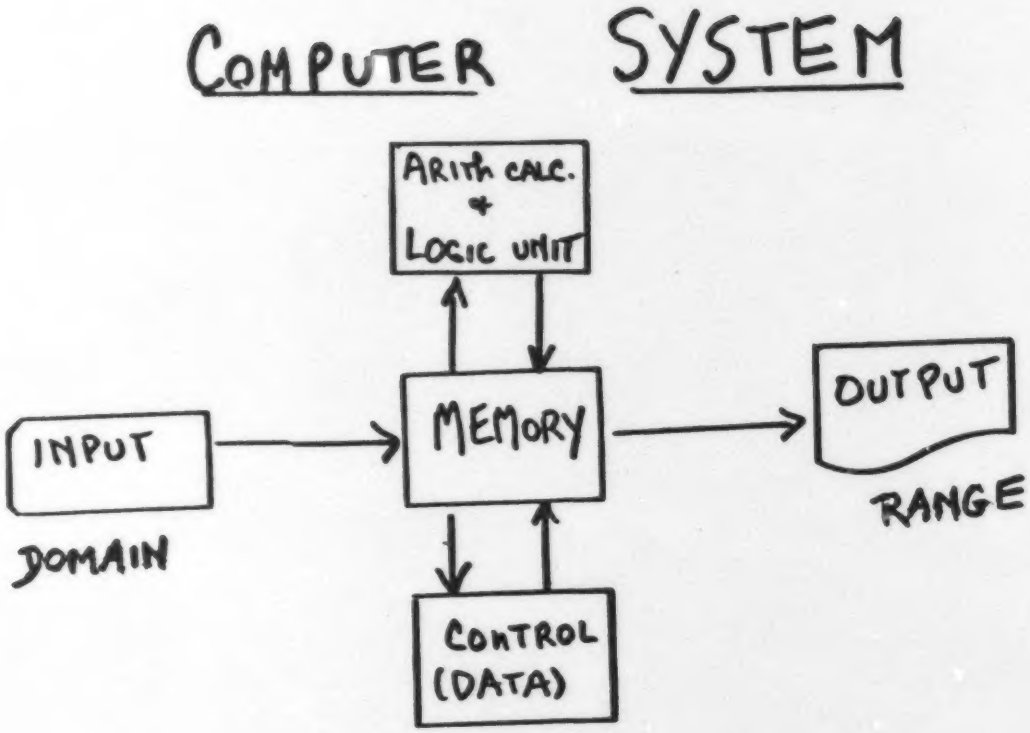
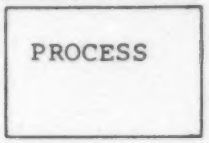


FIGURE 2... Computer Components

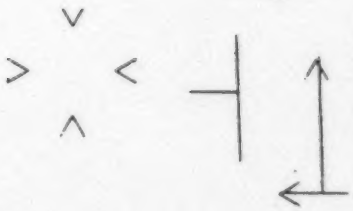
FLOW-CHART SYMBOLS USED IN TECH MATH

1. Basic Symbols:



Any processing function; defined operation(s) causing change in value, form, or location of information.

CONNECTOR: Exit to, or entry from, another part of the chart labeled 5 (changing #)



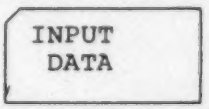
ARROWHEADS and FLOWLINES: In linking symbols, these show operations sequence and data-flow direction. Arrowheads are required if the path on any linkage is not left-to-right or top-to-bottom.

2. Symbols Related to Programming:

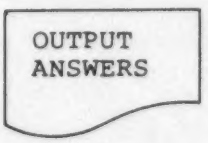
A decision or switching-type operation that determines which of a number of alternative paths are followed.

A terminal point in a flow-chart - start, stop, halt, delay, or interrupt.

3. Input/Output Symbols:



Input function for data. Card symbol is used although other hardware is available. This is preference of author.



Output function for answers. Torn sheet symbol is preference of author, although other hardware is available.

FIGURE 3... Flow-chart Symbols selected for class use in Tech Math

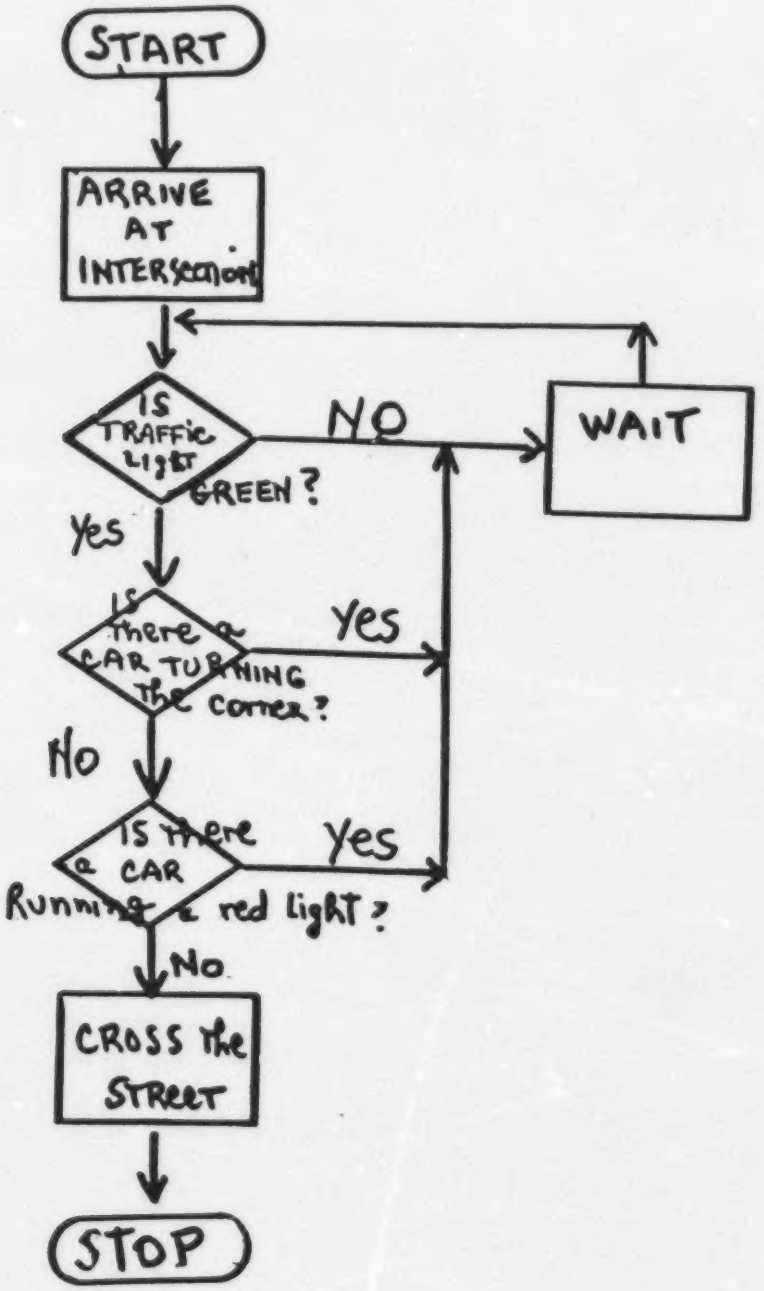


FIGURE 4... Procedure for Crossing Street at Intersection

ALGORITHM FOR CHANGING A TIRE

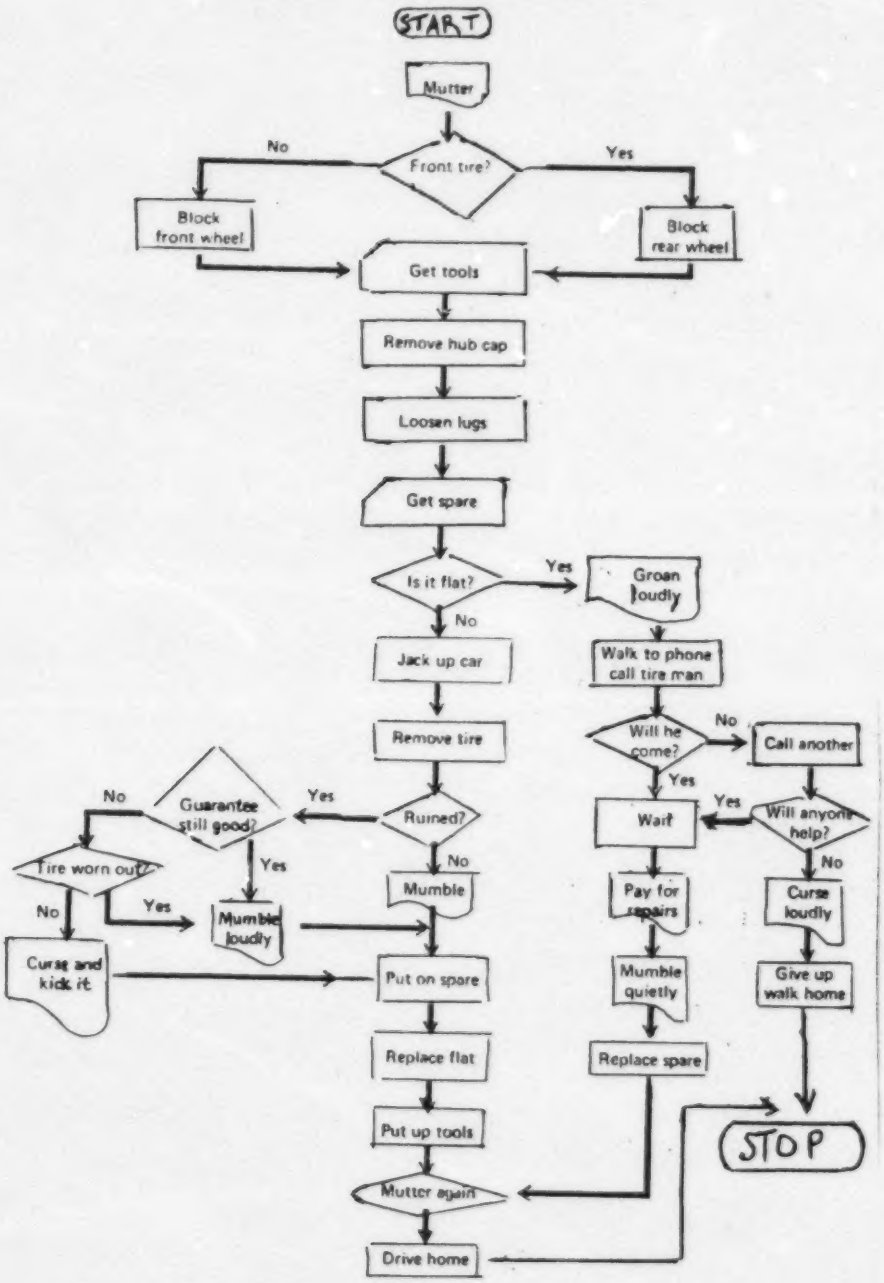
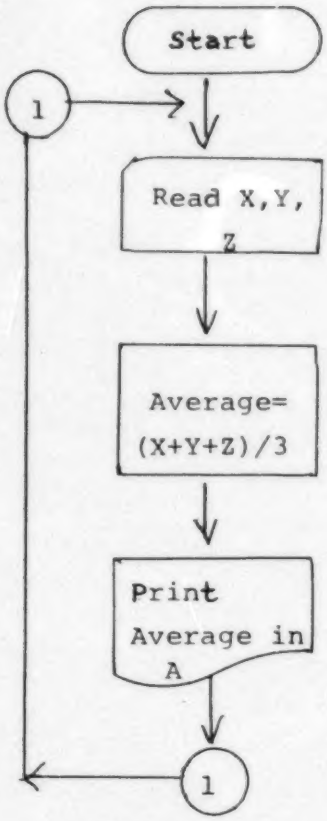


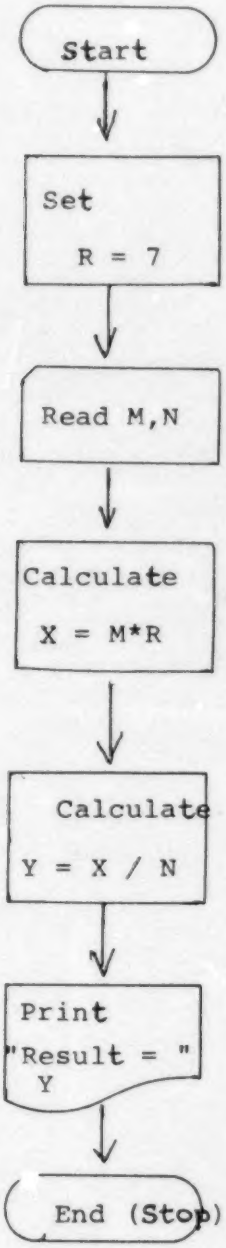
FIGURE 5... Flow of logic presented without geometrical symbols for students to fill-in in order to gain facility with concepts. Algorithm for changing a tire

TRACING PROBLEMS: SUBSTITUTION OF NUMBERS

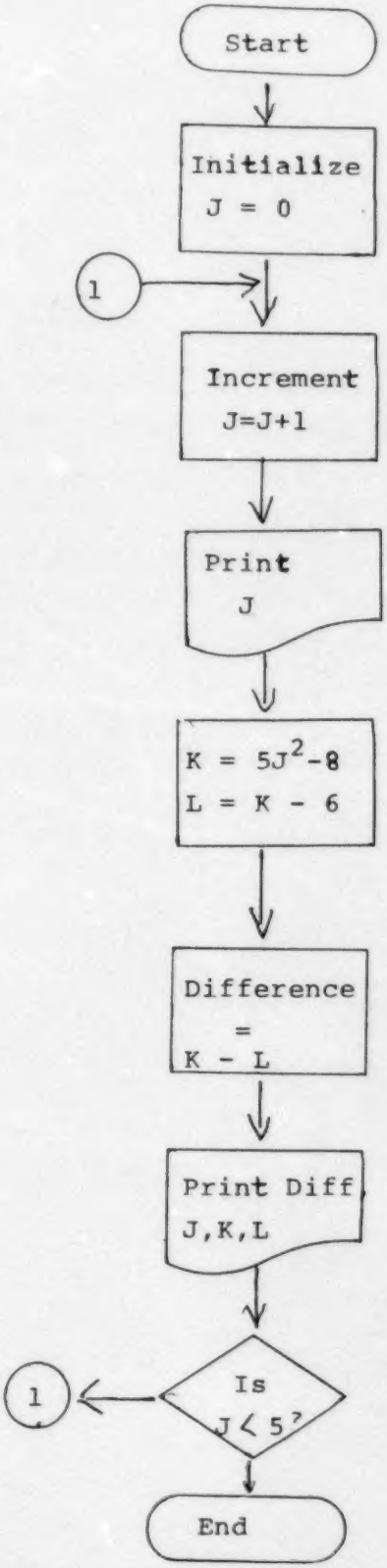


Flow-chart 6.1..
Finding the Average of Three Numbers

(Data supplied by instructor and answer traced by student through problem flow)



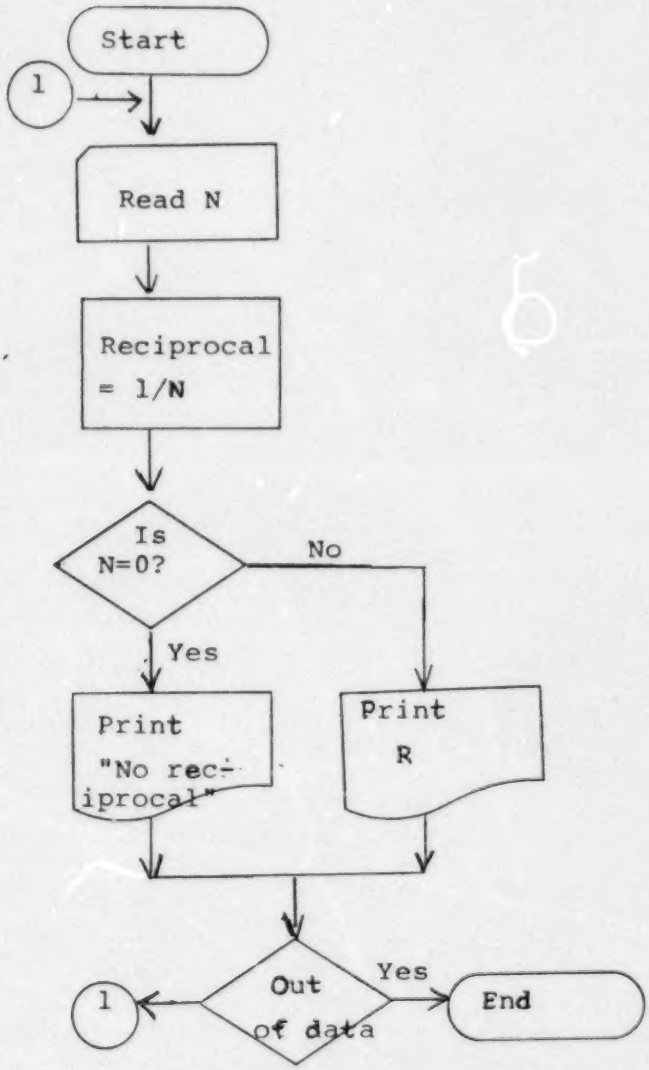
Flow-chart 6.2..
TRACE PROBLEM
Data Set:10,-5



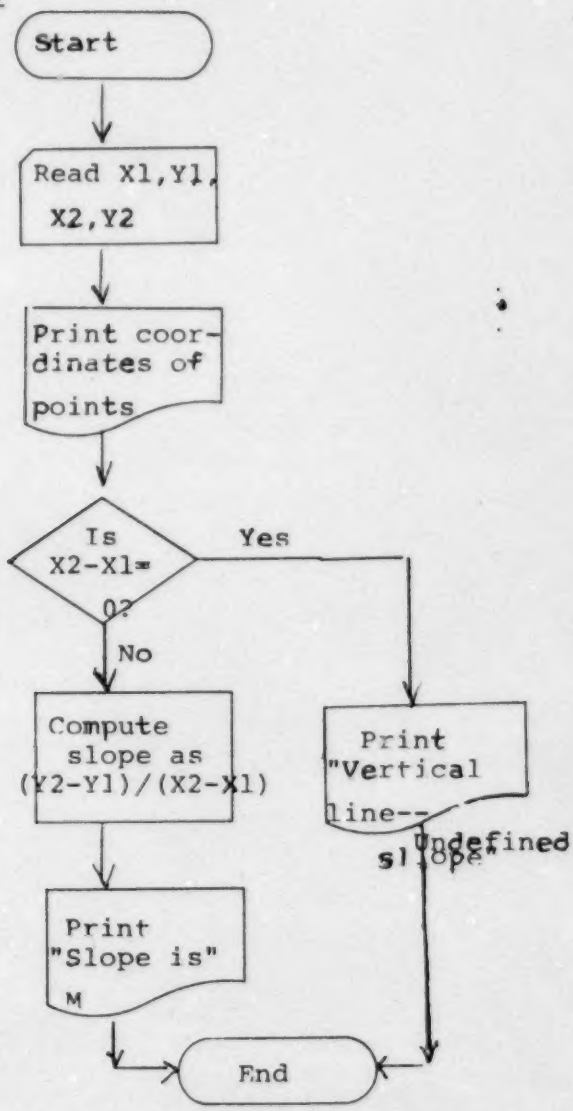
Flow-chart 6.3.. Trace Problem
Machine Generated Data

FIGURE 6... Tracing Problems Presented for Mathematical Substitution.

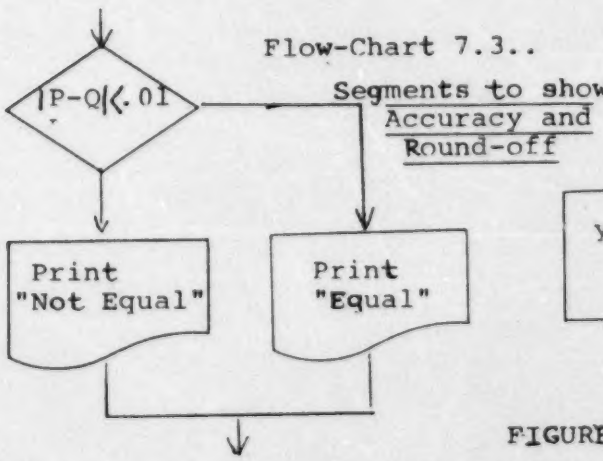
MATHEMATICAL DETAIL PROBLEMS



Flow-chart 7.1.. Read a number and print reciprocal if not zero.



Flow-chart 7.2.. Finding the slope of a given line



Flow-Chart 7.3.. Segments to show Accuracy and Round-off

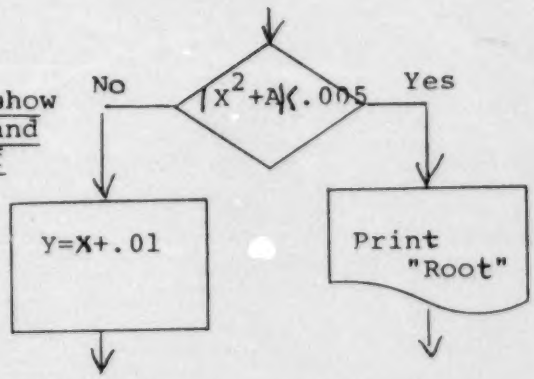
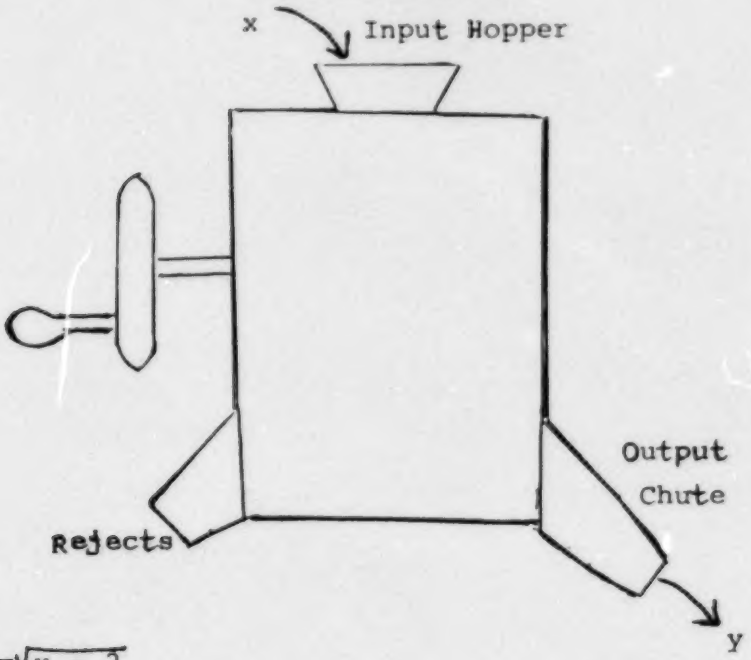


FIGURE 7... Mathematics Class Exercises

FUNCTION MACHINE



Given: $y = \sqrt{x - 2}$

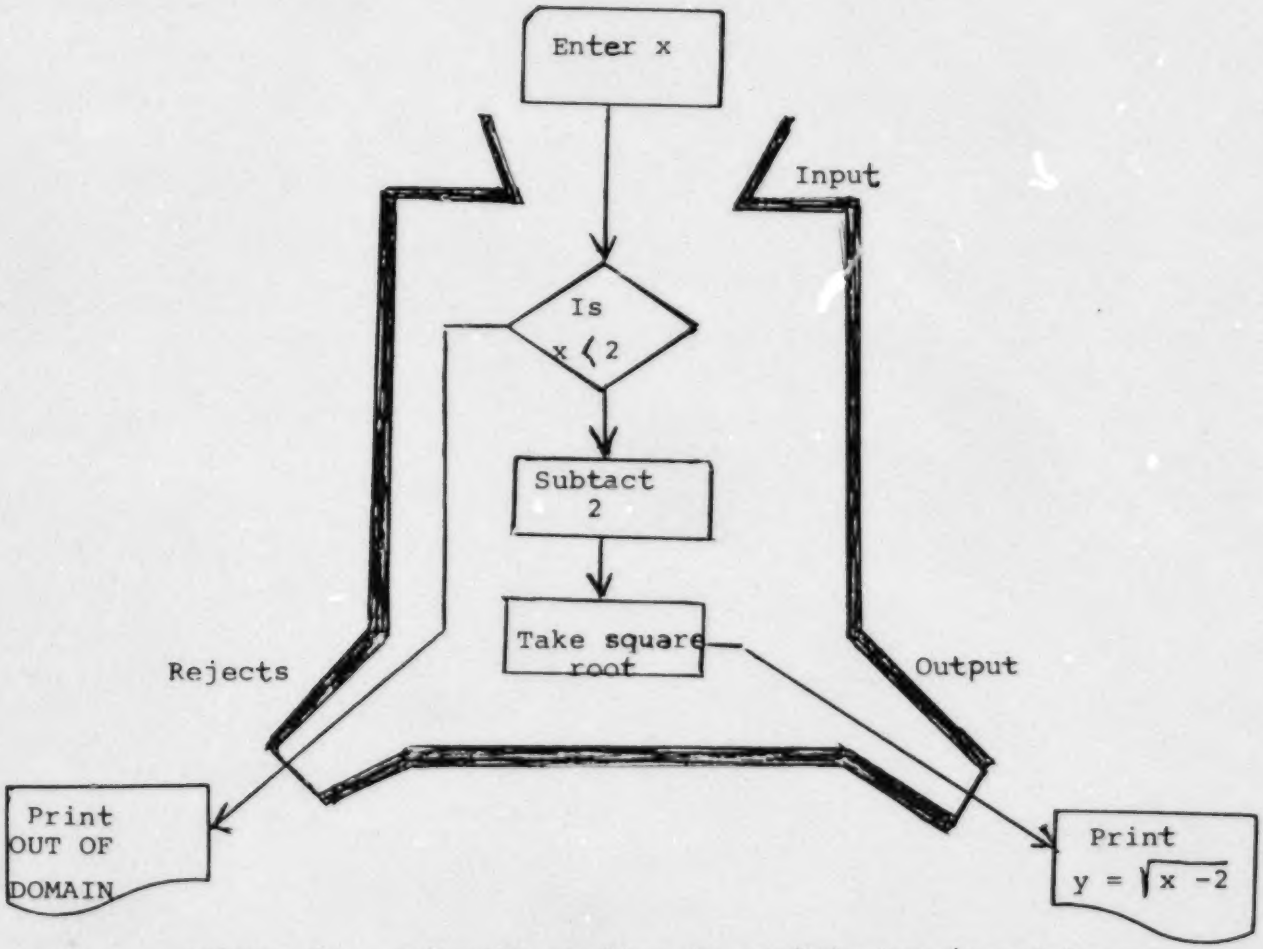
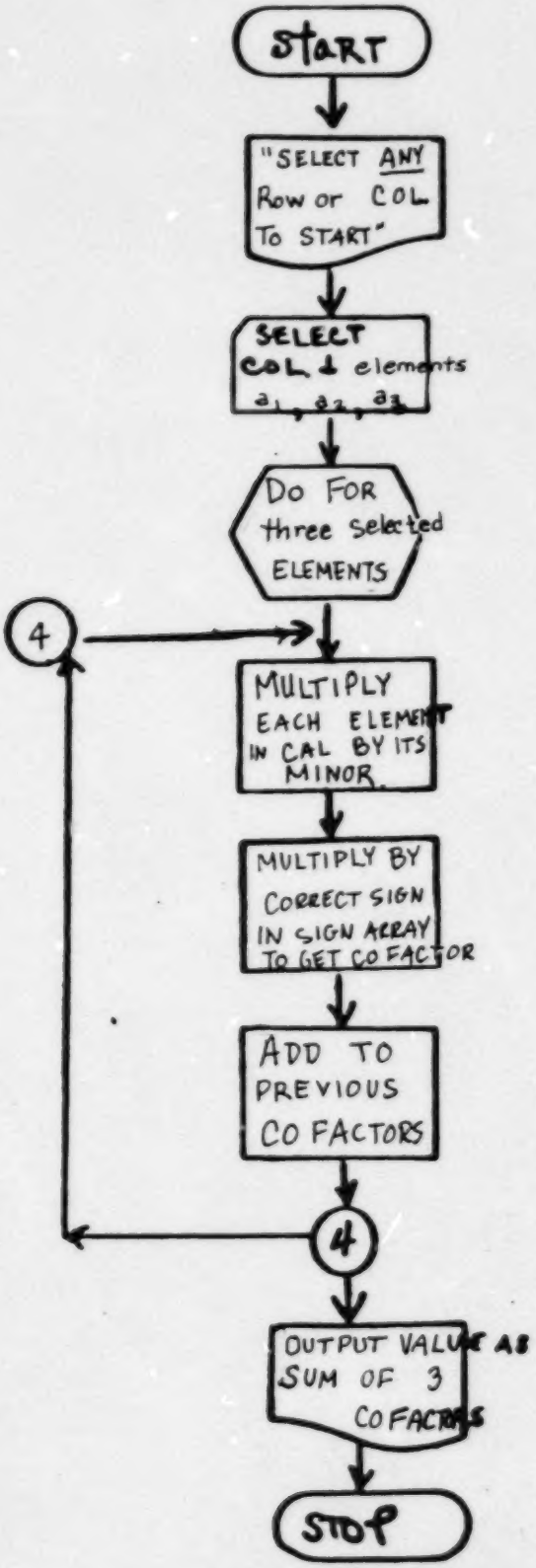


FIGURE 8... Function machine to explain Domain and Range

PROCEDURE TO SOLVE THIRD ORDER DETERMINANTS BY MINORS


START
"SELECT ANY Row or COL To START"
SELECT COL 1 elements a_1, a_2, a_3
Do FOR three selected ELEMENTS
4
MULTIPLY EACH ELEMENT IN CAL BY ITS MINOR.
MULTIPLY BY CORRECT SIGN IN SIGN ARRAY TO GET CO FACTOR
ADD TO PREVIOUS CO FACTORS
4
OUTPUT VALUE AS SUM OF 3 CO FACTORS
STOP

PROBLEM 1:

Evaluate the Determinant:

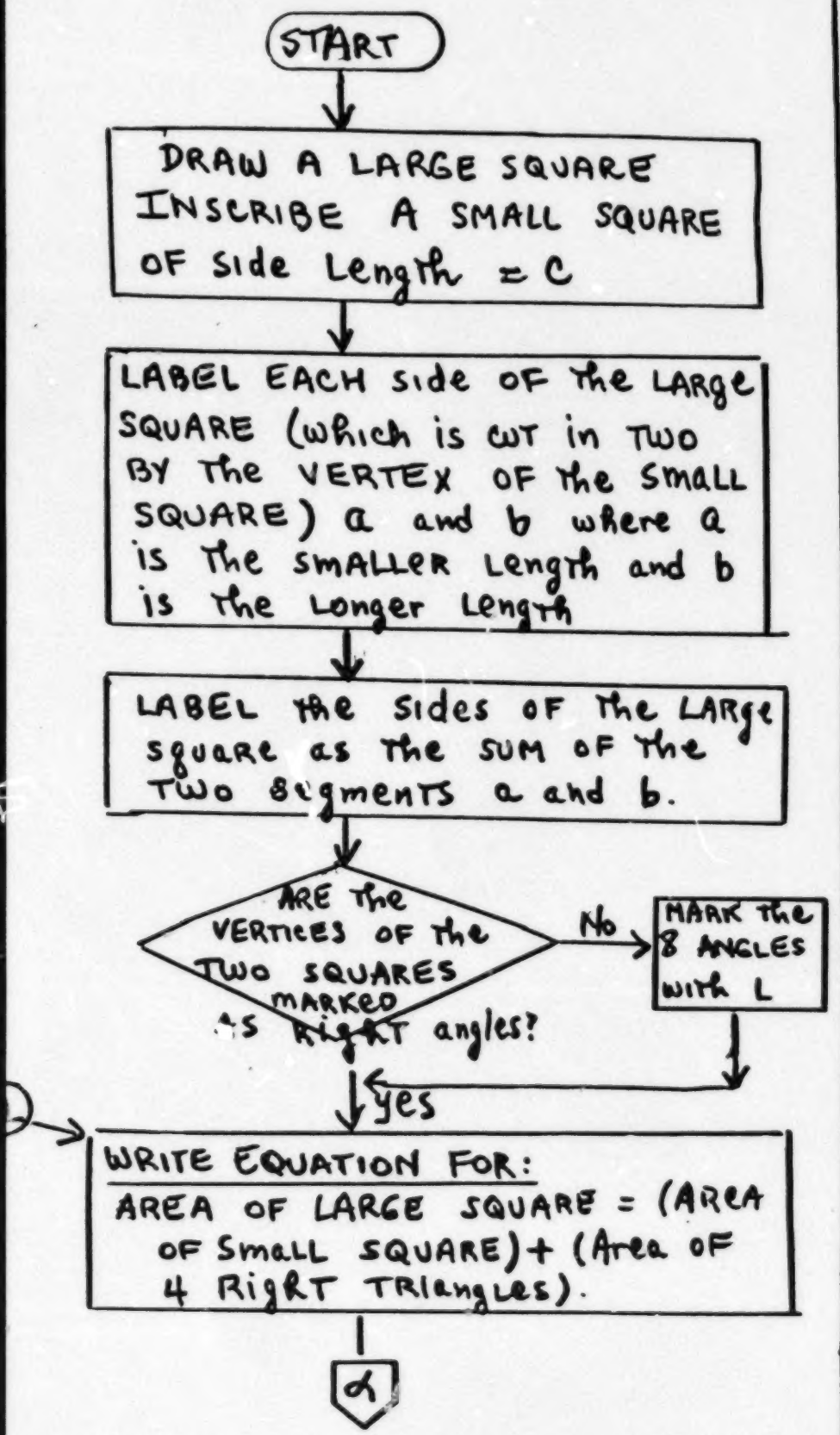
$$\begin{vmatrix} 2 & -1 & 3 \\ 3 & 0 & -5 \\ 2 & 1 & 1 \end{vmatrix}$$

VALUE OF DETERMINANT:

(The student fills in this side of hand-out using flow-chart)

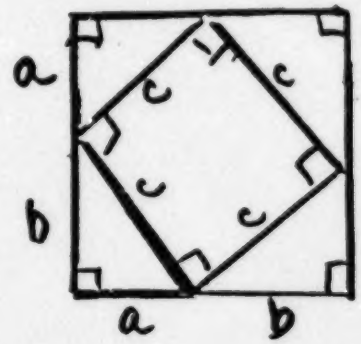
FIGURE 9.. Procedure used to solve Third Order Determinants used as handout for classroom work.

PROOF OF PYTHAGOREAN THEOREM


START
DRAW A LARGE SQUARE INSCRIBE A SMALL SQUARE OF Side Length = C
LABEL EACH side OF the LARGE SQUARE (which is cut in TWO BY The VERTEX OF the SMALL SQUARE) a and b where a is the SMALLER Length and b is the Longer Length
LABEL the Sides OF The LARGE square as the SUM OF the TWO Segments a and b.
ARE the VERTICES OF the TWO SQUARES MARKED AS RIGHT angles?
No
MARK the 8 ANGLES with L
Yes
WRITE EQUATION FOR:
AREA OF LARGE SQUARE = (AREA OF Small SQUARE) + (Area OF 4 RigRT TRIangles).
A

ALGEBRAIC EQUIVALENCE

Done By STUDENT in CLASS.

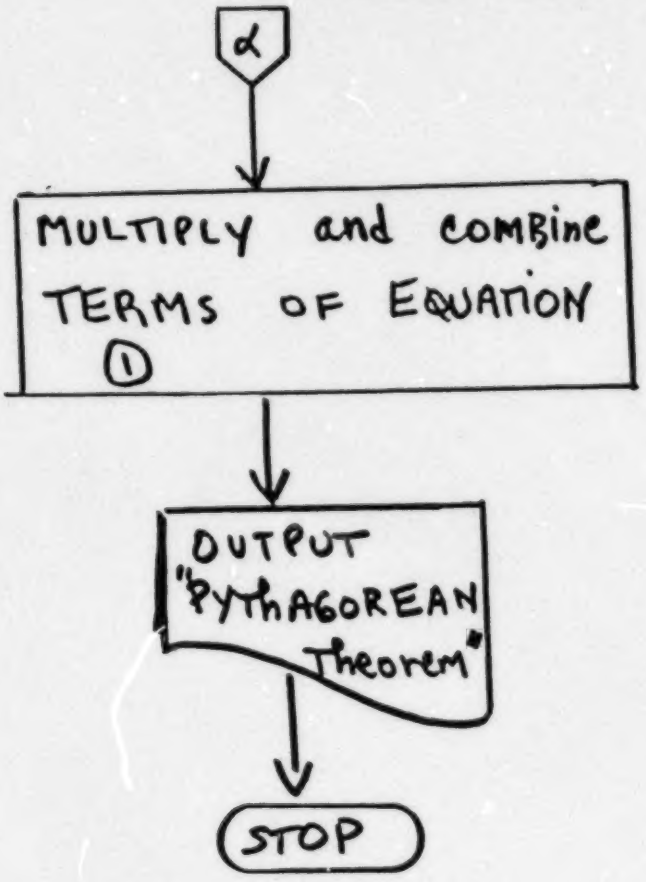


$(a+b)$

$(a+b)^2 = c^2 + 4\left(\frac{1}{2}\right)(b)(a)$

FIGURE10... Classroom exercise.. Proof of Pythagorean Theorem

PYTHAGOREAN THEOREM PROOF (continued)



ALGEBRAIC PROOF

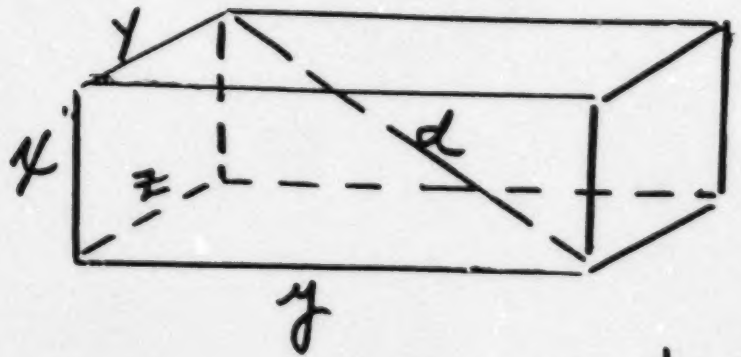
$a^2+2ab+b^2=c^2+2ab$ (2)

$a^2+b^2=c^2$

$\therefore$

$side^2+side^2=hyp^2$

Then extended TO Three dimensions



x = one dimension of rectangular Box

y = second dimension

z = depth OF Box

d = diagonal OF Box

$z^2+c^2=d^2$ where $x^2+y^2=c^2$

Assignment: PART A POLYNOMIAL EVALUATION

① FLOW CHART EVALUATION OF $Z = \sqrt{X+\sqrt{X+\sqrt{X+\sqrt{X+\sqrt{X}}}}}$

② RUN Program with given DATA

③ HAND IN FLOW CHART, LISTING, AND OUTPUT

PART B

EXTEND the PATTERN OF the EXPRESSION FOR Z to INCLUDE 10 X's. Then evaluate expression. THAT is

$$Z = \sqrt{X+\sqrt{X+\sqrt{X+\sqrt{X+\sqrt{X+\sqrt{X+\sqrt{X+\sqrt{X+\sqrt{X+\sqrt{X}}}}}}}}}}$$

This WILL necessitate CHANGING the Following Lines in Program:

40 change FIVE TO read ... TEN square ROOTS"

140 FOR I = 1 TO 9 (change 4 to 9)

Then

① RUN PROgram with given data

② HAND in LISTing And OUTPUT and FLOW CHART

PART C

EVALUATE the expression in PART A with RADICALS CHANGED TO CUBE ROOTS.

① Change Line 40 To read "..... SUM OF FIVE CUBE ROOTS"

② OMIT Lines 70, 80, 90, 100, 110, 120

③ CHANGE 130 TO READ: LET Z = X ↑ (1/3)

④ CHANGE 150 TO READ: LET Z = (X+Z) ↑ (1/3)

Then @ Run Program and ® Hand in Listing and Output and

FIGURE 11... Polynomial Evaluation with Listings (Homework assignment)

COMPUTER PROBLEM I : TECH MATH I

PROBLEM: GIVEN an integer VALUE OF X. CHECK that IT is NON-negative and CALCULATE VALUE OF Z.

$$Z = \sqrt{X+\sqrt{X+\sqrt{X+\sqrt{X+\sqrt{X}}}}}\,.$$

```
]LIST

20  REM  THIS PROGRAM EVALUATES T
     HE SQUARE ROOT FUNCTION
30  PRINT "NAME OF PROGRAMMER IS
     JOAN CAPPS AND THIS IS TECH
     MATH 1"
31  PRINT
32  PRINT
40  PRINT  TAB( 15):"EVALUATION O
     F SUM OF FIVE SQUARE ROOTS"
50  PRINT
60  READ X
70  IF X > 0 THEN 130
80  IF X = 0 THEN 110
90  PRINT "SQUARE ROOT OF ";X;" D
     OES NOT EXIST IN THE SET OF
     REAL NUMBERS."
91  PRINT
100  GOTO 50
110  PRINT "VALUE OF Z=0 SINCE X=
     0"
111  PRINT
120  GOTO 50
130  LET Z =  SQR (X)
140  FOR I = 1 TO 4
150  LET Z =  SQR (X + Z)
160  NEXT I
170  PRINT "WHEN X = ";X;", THEN
     Z = ";Z
171  PRINT
180  GOTO 50
190  DATA  4,5,0,-2,10,25,168,-10
     0,100,4,5,6,7,8
200  END
```

```
]RUN
NAME OF PROGRAMMER IS JOAN CAPPS AND THIS IS TECH MATH 1

                EVALUATION OF SUM OF FIVE SQUARE ROOTS

WHEN X = 4, THEN Z = 2.56071497

WHEN X = 5, THEN Z = 2.79070333

VALUE OF Z=0 SINCE X=0

SQUARE ROOT OF -2 DOES NOT EXIST IN THE SET OF REAL NUMBERS.

WHEN X = 10, THEN Z = 3.7013805

WHEN X = 25, THEN Z = 5.52490244

WHEN X = 168, THEN Z = 13.4711208

SQUARE ROOT OF -100 DOES NOT EXIST IN THE SET OF REAL NUMBERS.

WHEN X = 100, THEN Z = 10.5124896

WHEN X = 4, THEN Z = 2.56071497

WHEN X = 5, THEN Z = 2.79070333

WHEN X = 6, THEN Z = 2.99956718

WHEN X = 7, THEN Z = 3.19224805

WHEN X = 8, THEN Z = 3.37201472
```

```
30 LPRINT "THIS IS A CORRECTED CUBE ROOT PROGRAM.  GENE, HARRY,JOE,ET AL DISCOVE
RED THAT MICROS CANNOT TAKE NEGATIVE CUBE ROOTS"
31 LPRINT "ABSOLUTE VALUE FUNCTION IN 130 WILL CHANGE ALL VARIABLES TO POSITIVE.
  CHANGED PRINT STATEMENT WILL INDICATE NEGATIVE ANSWERS"
32 LPRINT
40 LPRINT TAB(15);"EVALUATION OF THE SUM OF FIVE CUBE ROOTS"
50 LPRINT
60 READ X
91 LPRINT
130 LET Z=ABS(X)[(1/3)
140 FOR I=1 TO 4
150 LET Z=ABS(X+Z)[(1/3)
160 NEXT I
161 IF X < 0 THEN 181
170 LPRINT "WHEN X= ";X;", THEN Z ="; Z
180 GOTO 50
181 LPRINT "WHEN X= ";X; ", THEN Z = -";Z
190 DATA 4,5,0,-2,10,25,168,-100,100,4,5,6,7,8
200 END
```

```
LLIST
RUN
THIS IS A CORRECTED CUBE ROOT PROGRAM.  GENE, HARRY,JOE,ET AL DISCOVERED THAT MI
CROS CANNOT TAKE NEGATIVE CUBE ROOTS
ABSOLUTE VALUE FUNCTION IN 130 WILL CHANGE ALL VARIABLES TO POSITIVE.  CHANGED P
RINT STATEMENT WILL INDICATE NEGATIVE ANSWERS

                EVALUATION OF THE SUM OF FIVE CUBE ROOTS


THIS IS A CORRECTED CUBE ROOT PROGRAM.  GENE, HARRY,JOE,ET AL DISCOVERED THAT MI
CROS CANNOT TAKE NEGATIVE CUBE ROOTS
ABSOLUTE VALUE FUNCTION IN 130 WILL CHANGE ALL VARIABLES TO POSITIVE.  CHANGED P
RINT STATEMENT WILL INDICATE NEGATIVE ANSWERS

                EVALUATION OF THE SUM OF FIVE CUBE ROOTS


WHEN X=  4 , THEN Z = 1.7963

WHEN X=  5 , THEN Z = 1.90415

WHEN X=  0 , THEN Z = 0

WHEN X= -2 , THEN Z = - 1.00345

WHEN X=  10 , THEN Z = 2.30891

WHEN X=  25 , THEN Z = 3.03796

WHEN X=  168 , THEN Z = 5.57826
```

"BUG" TECH MATH: Program For Nested Cube Roots

ERROR Due to CAN'T do $\sqrt[3]{}$ negative

```
20 REM THIS PROGRAM WILL TEST WHETHER CUBE ROOT PROGRAM AS GIVEN BY CAPPS INITIA
LLY IS A "GOOF" OR NOT.  IT IS BEING RUN ON THE TRS-80.
30 LPRINT "THIS IS A TEST OF THE NESTED CUBE ROOT PROGRAM.  IT IS BEING RUN ON T
HE TRS-80"
31 LPRINT
32 LPRINT
40 LPRINT TAB(15);"EVALUATION OF THE SUM OF FIVE CUBE ROOTS"
50 LPRINT
60 READ X
91 LPRINT
130 LET Z=X[(1/3)
140 FOR I=1 TO 4
150 LET Z=(X+Z)[(1/3)
160 NEXT I
170 LPRINT "WHEN X= ";X;", THEN Z= "; Z
171 LPRINT
180 GOTO 50
190 DATA 4,5,0,-2,10,25,168,-100,100,4,5,6,7,8
200 END
```

→ note ORDER of OPS MUST Be Preserved with ( )

```
THIS IS A TEST OF THE NESTED CUBE ROOT PROGRAM.  IT IS BEING RUN ON THE TRS-80

                EVALUATION OF THE SUM OF FIVE CUBE ROOTS

WHEN X=  4 , THEN Z=  1.7963


WHEN X=  5 , THEN Z=  1.90415


WHEN X=  0 , THEN Z=  0
```

STOPPED on Function error - ie doing calculation $\sqrt[3]{-2}$ [can't take $\sqrt[3]{}$ of negative]

Roots of A Quadratic Equation:

Read real numbers A, B, C, which are coefficients of a quadratic equation $Ax^2 + Bx + C = 0$. If the equation has one or more real roots compute and print the root(s), labeling them REAL. If roots are complex, CALCULATE and LABEL.

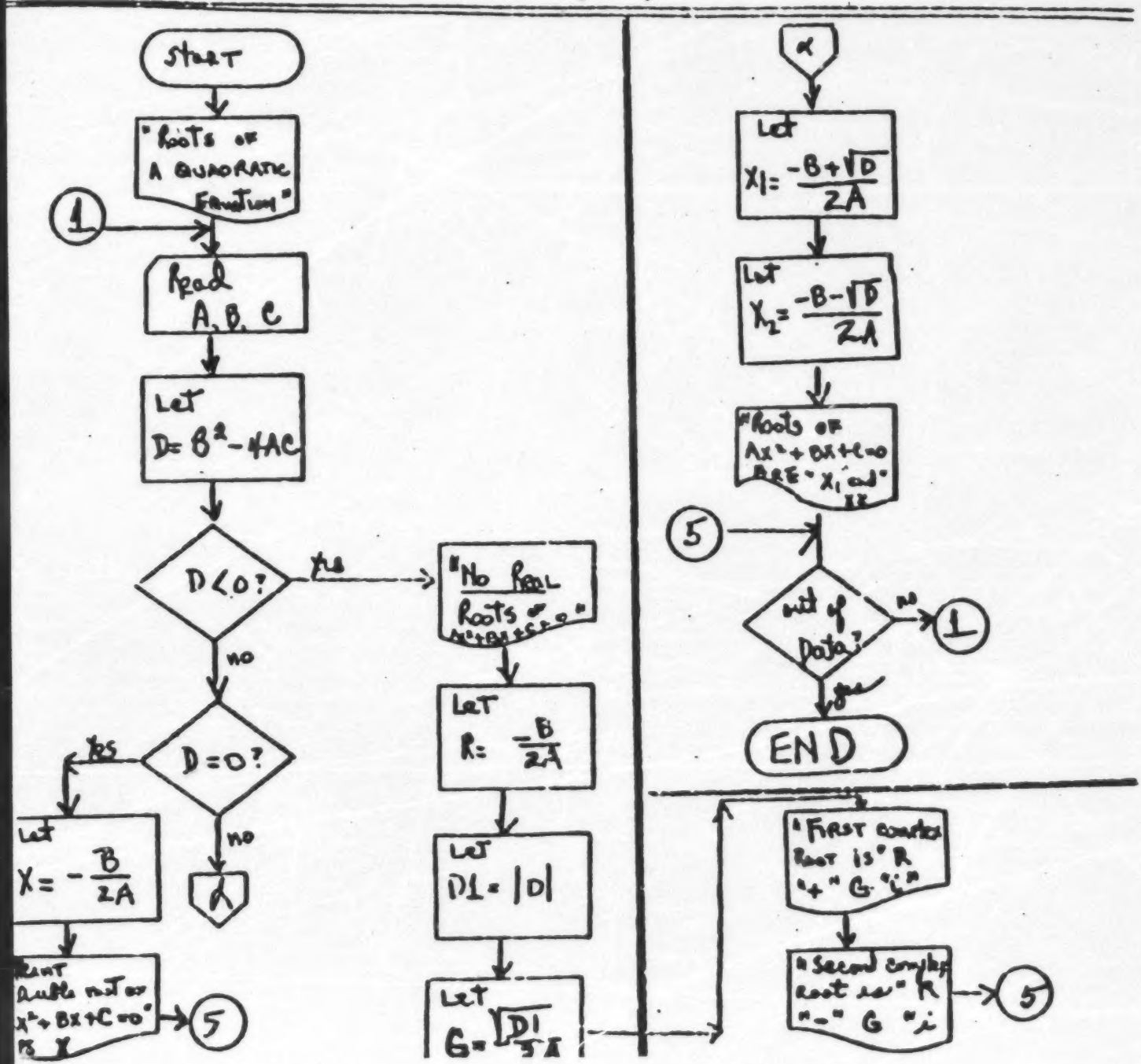


FIGURE 12... Quadratic Equation Homework Problem

Assignment:

① List and RUN Program with data Given in Problem:

@ CHECK MACHINE CALCULATIONS BY SOLVING BY HAND:

$1x^2 - 5x + 6 = 0$ [FIRST SET OF 3 data value

$3x^2 - 5x + 4 = 0$ [second set of 3 data values

$1x^2 - 4x + 4 = 0$ [third set of 3 data values

HAND IN these CALCULATIONS with LISTING and RUN.

② WHEN you have checked all CALCULATIONS, Do ALL PROBLEMS # 1 — 24 on pgs 162 and 163 using APPROPRIATE DATA STATEMENT. Answers should check with Answers in the back of the book. Also, page 164/# 37 — 46.

Example .. Replace Data statement LISTED with:

21# DATA 1, 2, -8, 1, -1, -6, 1, 8, 2, 1, 5, -6 (etc for 24 problems)

Notes

① IF the DATA LIST is too long for one line it may be broken into several lines, BUT each line must be numbered and the word DATA repeated each Time. For ex.

21#/DATA 1, 2, -8, 1, -1, -6, 1, 3, 2, 1, 5, -6

215/ DATA 1, -4, 2, 1, 10, -4

② Note that data STATEMENT CONTAINS NUMBERS only - NOT letters CALLED 'STRING VARIABLES' so cannot do Problems such as page 169/25, 26, 29 using this technique

FLOW CHART TO SOLVE WORD PROBLEMS

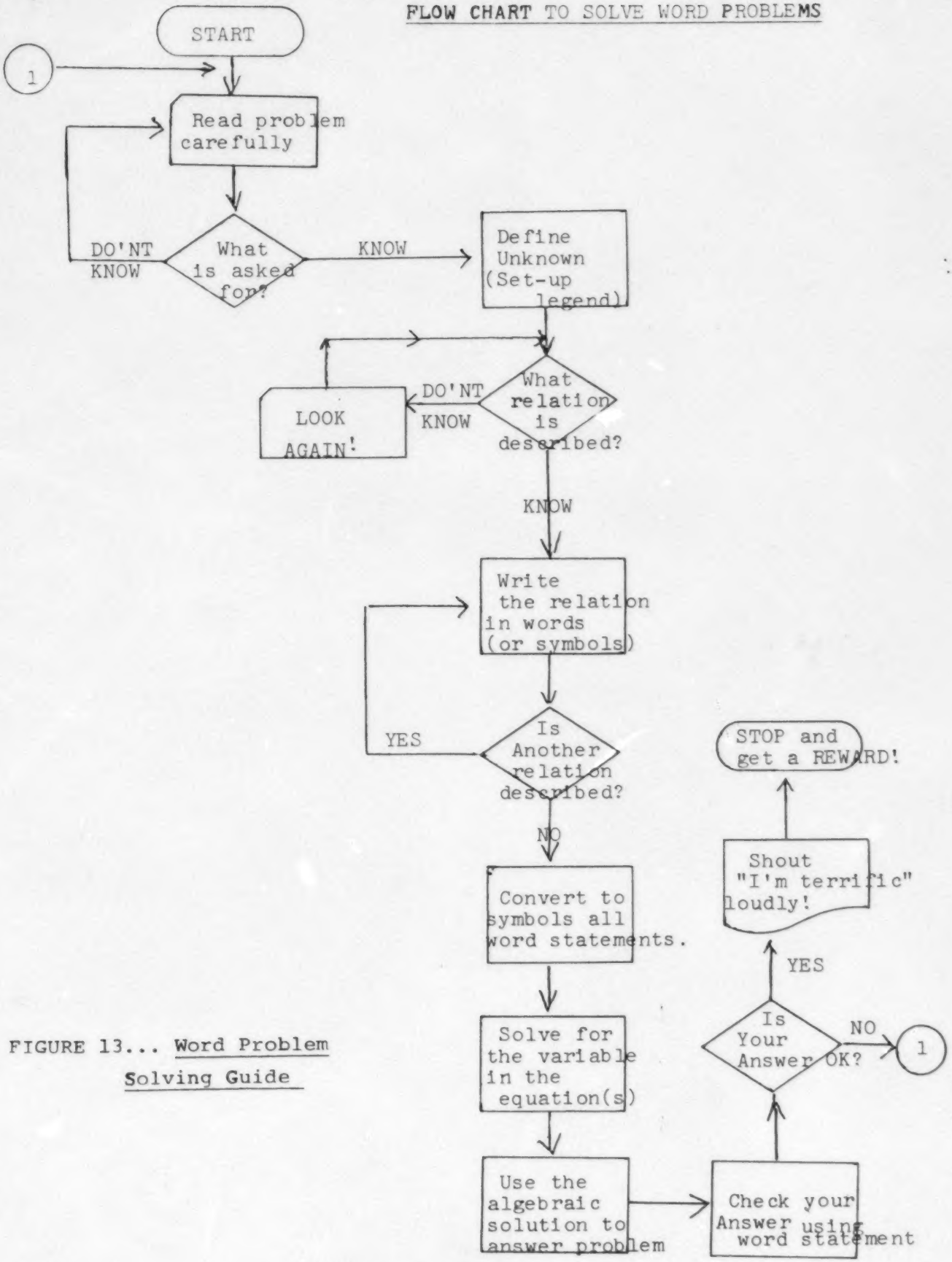


FIGURE 13... Word Problem Solving Guide

ERIC Clearinghouse for Junior Colleges DEC 13 1984